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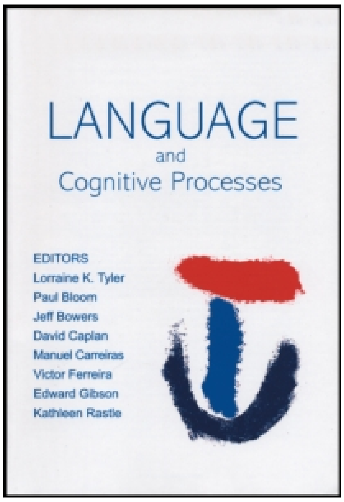

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Co-speech gesture in bimodal bilinguals

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The effects of knowledge of sign language on co-speech gesture were investigated by comparing the spontaneous gestures of bimodal bilinguals (native users of American Sign Language and English; $n = 13$) and non-signing native English speakers ($n = 12$). Each participant viewed and re-told the *Canary Row* cartoon to a non-signer whom they did not know. Nine of the thirteen bimodal bilinguals produced at least one ASL sign, which we hypothesise resulted from a failure to inhibit ASL. Compared with non-signers, bimodal bilinguals produced more iconic gestures, fewer beat gestures, and more gestures from a character viewpoint. The gestures of bimodal bilinguals also exhibited a greater variety of handshape types and more frequent use of unmarked handshapes. We hypothesise that these semantic and form differences arise from an interaction between the ASL language production system and the co-speech gesture system.

Bimodal bilinguals know both a signed language and a spoken language (Emmorey, Borinstein, Thompson, & Gollan, 2008; Messing, 1999). When bimodal bilinguals talk with each other, they rarely code-switch between sign and speech, but instead produce code-blends in which signs and words are

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articulated simultaneously (Bishop, 2006; Emmorey et al., 2008). Unlike code-switching, code-blending shares certain properties with co-speech gesture. Specifically, co-speech gestures, like code-blends, are meaningful manual productions that are articulated concurrently with spoken words. In addition, Emmorey et al. (2008) found that code-blends resembled co-speech gesture with respect to synchronous vocal-manual timing and co-expressiveness (in general, the same concept is encoded by signs and words within a code-blend). Given these parallels between bilingual code-blending and co-speech gesture, we investigated whether the nature of co-speech gesture for bimodal bilinguals is affected by their knowledge and use of a signed language. Specifically, we examined the co-speech gestures produced by hearing English speakers who are also native users of American Sign Language (ASL) when they are speaking to someone who does not know any ASL. In this situation bimodal bilinguals are unlikely to code-blend (or to code-switch) because their conversational partner is a non-signer.

Previously, in an unpublished master's thesis, Naughton (1996) investigated the co-speech gestures produced by a late-learner of ASL who was paired with an English speaking non-signer in a conversational dyad in which participants discussed a recent event. Naughton found that the bilingual participant produced a few clearly identifiable ASL signs, even though her conversational partner did not know ASL. The timing of ASL signs matched that of co-speech gesture in that the preparation and stroke often began just before the semantically related word. Based on the timing of ASL signs with speech and the fact that signs were produced even when interacting with a non-signer, Naughton hypothesised that signs were replacing co-speech gesture for this fluent ASL–English bilingual.

The current study was designed to more rigorously assess Naughton's findings by examining a larger cohort of fluent ASL–English bilinguals and by directly comparing signers and non-signers in the same narrative context. We hypothesise that the existence of co-speech gesture allows the 'intrusion' of ASL signs when speaking to a non-signer. Mounting evidence indicates that bilinguals cannot completely shut off or inhibit one language while speaking another (Colome, 2001; Costa, 2005; Hermans, Bongaerts, de Bot, & Schreuder, 1998). Although both spoken languages may be active within the mind of a unimodal bilingual, unintentional code-switches to a language unknown to their interlocutor are extremely rare (Poulisse, 1997). In contrast, we predict that bimodal bilinguals will produce unintentional code-blends, which will appear as co-speech gesture to their interlocutor.

In addition to determining whether bimodal bilinguals produce ASL signs when speaking with non-signers, we also wanted to determine whether the co-speech gestures produced by bimodal bilinguals are influenced by the properties and characteristics of ASL. That is, do ASL–English bilinguals

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gesture differently from non-signing English speakers? If so, it will indicate that use of a signed language can impact the nature of co-speech gesture. We hypothesise that an interaction between the ASL language production system and the co-speech gesture system can give rise to differences in both the content and the form of co-speech gestures produced by bimodal bilinguals. Emmorey et al. (2008) propose a model of bimodal bilingual language production based on Levelt's speech production model (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999) that also incorporates the model of co-speech gesture production proposed by Kita and Özyürek (2003). The model is shown in Figure 1.

The model assumes separate but linked language production systems (Formulators) for ASL and English (see Emmorey, 2007, for evidence that Levelt et al.'s model can be adapted for sign language production). Kita and Özyürek (2003) propose that co-speech gestures arise from an Action Generator (a general mechanism for creating an action plan), which interacts with the Message Generator within the speech production system. By proposing that the Action Generator interacts with the Message Generator, Kita and Özyürek's model accounts for the fact that language can constrain the form of gesture. For example, Turkish speakers produce manner of motion gestures that differ from those of English speakers because Turkish encodes manner with a separate clause whereas English encodes manner and path information within the same clause. Thus, English speakers tend to

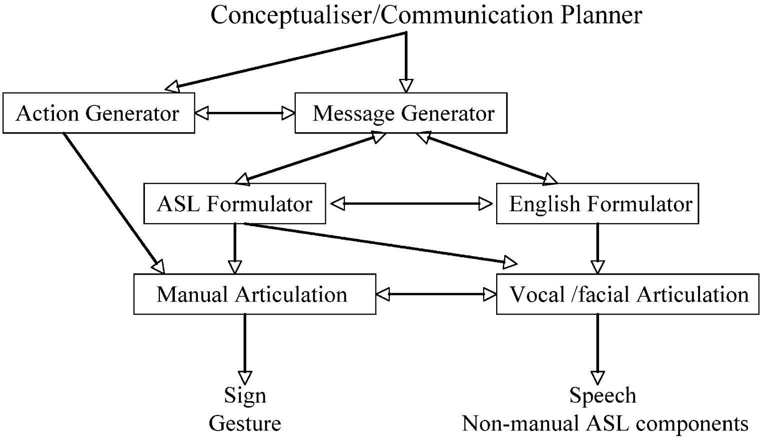

Figure 1. The model of ASL–English code-blend production proposed by Emmorey et al. (2008). The model is based on Levelt's (1989) model of speech production and integrates Kita and Özyürek's (2003) model of speech and gesture production. Connections to the Action Generator from the Environment and Working Memory are not shown. The ASL and English Formulators are hypothesised to contain the lexicons and grammatical, morphological, and phonological encoding processes for each language.

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produce gestures that conflate manner and path information, while Turkish speakers produce separate gestures to express manner and path (Özyürek, Kita, Allen, Furman, & Brown, 2005).

Within the model proposed by Emmorey et al. (2008), knowledge and use of ASL can affect the content of co-speech gesture via the Message Generator. The Message Generator packages semantic, relational, and perspective meaning into a preverbal message (Bock, 1982; Levelt, 1989). Preverbal messages contain the information that speakers intend to express in their linguistic utterances. For expressions of location and motion, ASL signers most often produce classifier constructions in which the signer's hands iconically depict the motions, locations, and shapes of objects. That is, the movement of the hand depicts the motion of an object, the spatial relation between the hands indicates the spatial relation between objects, and the handshape is often an iconic representation of the shape of the object – see papers in Emmorey (2003). Several studies have shown that iconic co-speech gestures are produced most frequently when speakers talk about events or states that involve spatial information (Alibali, Heath, & Myers, 2001; Kita & Özyürek, 2003; Morsella & Krauss, 2004; Rauscher, Krauss, & Chen, 1996; Trafton, Trickett, Stitzlein, Saner, Schunn, & Kirschenbaum, 2006; Wesp, Hesse, Keutmann, & Wheaton, 2001). Because the Action Generator interfaces with the Message Generator, we hypothesise that ASL–English bilinguals are primed to produce iconic co-speech gestures. The Message Generator for ASL routinely encodes relatively analogue representations of spatial information due to the depictive and iconic properties of classifier constructions (and for some lexical signs as well, see Liddell, 2003). As a result, ASL signers are accustomed to using their hands to depict the motions, locations, and shapes of referents in a discourse. Therefore, we predict that bimodal bilinguals will produce more iconic co-speech gestures compared with non-signers. In addition, given that ASL pronouns are directed toward locations in signing space associated with referents, we predict that bimodal bilinguals will also produce more deictic gestures while speaking.

However, we do not expect that signers and non-signers will differ with respect to beat gestures. McNeill (1992) defines beats as gestures that move with the rhythmic pulsation of speech and index the accompanying speech as significant. There are no signs that perform such a function since ASL is not linked to a co-expressive system. Thus, there is no obvious linguistic structure that might prime the production of beat gestures by bimodal bilinguals.

We also predict that bimodal bilinguals will produce more two handed iconic gestures in which each hand represents a distinct referent, because they habitually produce ASL classifier constructions in which each hand represents a separate entity. For example, to indicate a cat jumping onto a

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bed, the signer's dominant hand would represent the cat with a bent V handshape specifying an animal, and the non-dominant hand would represent the bed with a B handshape specifying a flat surface-prominent object (see Appendix A for illustrations of handshapes). The hand representing the cat would then be moved onto the top of the hand representing the bed. Classifier constructions expressing the location and/or movement of two objects with respect to each other are commonly produced with two hands, each hand denoting a different referent.

Finally, we predict that bimodal bilinguals will be more likely to produce gestures from a character viewpoint. When adopting a character viewpoint, the gesturer's body is used as if he or she were a character in the narrative (McNeill, 1992). Similarly, in ASL narratives, the point of view of a character can be conveyed by *role shift* (or *referential shift*), a discourse device expressed by a break in eye gaze and often a slight shift in body position (Friedman, 1975; Padden, 1986). After marking a role shift, the affective facial expressions and gestural body movements of the signer are interpreted as those of a character in the narrative. Because the Message Generator for ASL must frequently encode character perspective for linguistic expression in ASL, we hypothesise that the interface between the Message Generator and the Action Generator will result in an increase in the use of character perspective gestures by bimodal bilinguals when speaking English.

In the Emmorey et al. (2008) model, both the Action Generator and the ASL Formulator feed into the same manual articulation system (see Figure 1). The Action Generator creates spatio-motoric representations that are sent to the motor control system for expression as co-speech gestures (Kita & Özyürek, 2003), while the ASL production system sends phonological representations to the same system for expression as lexical signs. ASL–English bilinguals are experienced in using a wide variety of hand configurations to express meaning with lexical signs, and therefore the Action Generator may create meaningful gestures utilising a wider variety of handshape types. Thus, we predict that bimodal bilinguals will produce more varied handshapes in their co-speech gestures than speakers who are not signers. Bimodal bilinguals are practiced with a number of unusual handshapes (e.g., a Y handshape), and they may draw on these handshapes when creating co-speech gestures. However, we also predict that bimodal bilinguals will produce the majority of co-speech gestures with handshapes that are unmarked in ASL. Unmarked handshapes are the most common handshapes in sign languages cross-linguistically (Battison, 1978), are the most frequently occurring handshapes in signs, i.e., they occur in approximately 70% of signs (Klima & Bellugi, 1979), and are acquired first by children learning a sign language as a native language (Boyes-Braem, 1990). We hypothesise that the common use of unmarked handshapes within ASL signs may prime the Action Generator to select such handshapes when creating co-speech gestures. In sum, we predict that bimodal bilinguals will use more varied handshape types, but most gestures will be articulated with unmarked handshapes, as are most ASL signs.

Lastly, we predict that bimodal bilinguals will produce more co-speech gestures than speakers who are not signers. ASL–English bilinguals are likely to have an increased gesture rate because of their experience producing meaningful information with their hands (ASL signs). In addition, Pika, Nicoladis, and Marentette (2006) recently argued that knowledge of a language whose speakers produce a high rate of gesture (e.g., French or Spanish) increases gesture rate in a low frequency gesture language, such as English. However, it should be noted that no baseline measures exist for categorising a language as 'high gesture' or 'low gesture'. Nonetheless, one could consider ASL a high gesture language compared to English simply by virtue of its modality, i.e., semantic information is continually and consistently expressed by manual gestures in ASL. On this view, ASL might be considered simply a 'manual-expression heavy' language, rather than a 'gesture heavy' language. On the other hand, several linguistic analyses of ASL hypothesise that the production of pronouns, agreeing (or indicating) verbs, and classifier constructions require access to a 'co-sign' gesture system. Specifically, these forms are hypothesised to be a hybrid of linguistic and gestural components (Liddell, 2003; Lillo-Martin, 2002; Mathur, 2002; Rathmann & Mathur, 2002; Sandler & Lillo-Martin, 2006). For example, when signers use a pronoun to refer to a present referent, the pronoun is directed toward that person or thing. The form of the handshape is linguistically specified (e.g., a 1 handshape for a personal pronoun or a B handshape for a possessive pronoun), but the direction of the pronoun is determined by an interface with representational gesture (i.e., deictic reference). Similarly, gradient spatial information can be conveyed by locative classifier constructions, and the locations in signing space for such constructions is best analysed as a gestural overlay, rather than as the production of categorical morphemes (e.g., Emmorey & Herzig, 2003). Therefore, ASL signers often produce gestural information while signing (see also Emmorey, 1999). If these analyses are correct and ASL is appropriately considered a high-frequency gesture language (or even simply a 'manual-expression heavy' language), then we predict a higher gesture rate for ASL–English bilinguals compared with non-signing English speakers.

In sum, we predict that the co-speech gesture of bimodal bilinguals will differ from non-signers by containing (a) ASL signs, (b) a higher rate of gesture, (c) more iconic and deictic gestures, (d) more two-handed gestures that represent two entities, (e) more gestures from a character viewpoint, (f) a greater variety of handshape types, and (g) more gestures with unmarked handshapes. Knowledge and frequent use of ASL is predicted to affect both the content and form of co-speech gesture, even when speaking with

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interlocutors who are sign naïve. If our predictions are borne out, this would constitute evidence supporting the following hypotheses: (1) a non-selected language (i.e., ASL) is not completely suppressed when producing the selected language (English), (2) the Message Generator for a non-selected language can influence the semantic content of co-speech gestures via an interface with the Action Generator, and (3) shared access to manual articulation by the ASL Formulator and the Action Generator impacts the form of co-speech gestures for bimodal bilinguals.

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METHOD

Participants

Thirteen ASL–English bilinguals with normal hearing participated in the study (four males; nine females). All were born into Deaf signing families and acquired ASL as a first language. Twelve hearing native English speakers who had no knowledge of ASL also participated (three males; nine females). Six of the non-signing participants were from McNeill's original (1992) study of co-speech gesture, which followed the same procedure outlined below.

Procedure

Participants were shown a 7-minute Tweety and Sylvester cartoon (*Canary Row*) and asked to re-tell the entire cartoon to another person whom they did not know.[1] The interlocutor was either a naïve listener who had not viewed the cartoon or a confederate (for five of the monolingual participants). The interlocutor was instructed to listen to the story and interact with the participant naturally, i.e., asking questions if something was unclear and providing feedback to indicate comprehension. The bimodal bilinguals were aware that their interlocutor did not know sign language. Participants were videotaped for later coding and analysis.

Gesture coding

Gestural productions were coded for the following properties: ASL signs versus non-sign gestures; iconic, deictic, and beat types; character and observer viewpoints; and handshape form. Inter-rater agreement was based on two raters independently coding one bimodal bilingual or one non-signing subject's data for each of these properties.

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[1] Bimodal bilingual participants also re-told the cartoon to another ASL–English bilingual whom they knew. Whether participants initially interacted with a bilingual or a non-signing partner was counter-balanced across participants. Results from the bilingual condition are presented in Emmorey et al. (2008).

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Productions were coded as ASL signs when they were identifiable lexical signs (e.g., CAT or BIRD) or classifier constructions that a non-signer would be unlikely to produce. For example, a bent V handshape is used in ASL as a classifier for animals. Since this type of handshape is not commonly found with this meaning in the gesture of non-signers, this form was coded as a sign when used to represent an animal, but it was not counted as a sign in other contexts (e.g., in a gesture describing an electric shock). On the other hand, non-signers often use the V handshape with fingertips pointing downward to represent someone walking, so this form was not coded as an ASL sign. Inter-rater agreement for classifying forms as ASL signs or non-sign gestures was 88.10% based on 84 independently coded gestures. (See Appendix B for a list of forms that were coded as ASL signs.)

Gestures were classified by type as iconics, deictics, beats, conventional, and unknown. Gestures were coded as *iconic* when they resembled what they represented. For example, tracing the shape of Tweety's cage or moving the hand in a horizontal sweeping motion to describe Sylvester's movement down the street. For iconic gestures, we also coded whether each hand referred to a separate referent. For example, one hand could refer to Sylvester and the other to Tweety (e.g., to show their relative spatial arrangement), or one hand could refer to Sylvester holding a suitcase and the other hand could refer to Sylvester holding a birdcage. Gestures that were imitations of those performed by characters in the cartoon were also coded as iconic, e.g., moving the index finger from side to side, mimicking Sylvester's gesture in the cartoon. Pointing gestures produced with a fingertip or the hand were coded as *deictics*. This type of gesture could point at something physically present or not. Non-iconic gestures that jabbed or bounced in synchronisation with speech were coded as *beats*. These could be composed of multiple movements or just a single movement, but they usually accompanied a stressed word. Gestures that are often used in American culture, e.g., thumbs up, shh, and so-so, were coded as *conventional* gestures. Lastly, gestures that were unclassifiable were coded as *unknown*, e.g., a gesture that looked like a beat, but was produced without accompanying speech. However, these gesture categories were not mutually exclusive. It was possible for a gesture to be coded as belonging to more than one category. For example, one participant held out his hand imitating Sylvester holding out a tin cup and bounced his hand with the accompanying speech 'and takes his um tin cup'. This was coded as both an iconic and a beat gesture. Inter-rater agreement for gesture type was 86.36% based on 132 independently coded gestures.

Gestures were coded as containing character viewpoint if they were produced from the perspective of a character, i.e., produced as if the gesturer were the character. For example, moving two fists outward to describe Sylvester swinging on a rope. Character viewpoint gestures included both manual gestures and body gestures not involving the hands. For example, moving the torso side to side to describe Sylvester rolling down the street with a bowling ball inside him. Gestures could also simultaneously contain both an observer viewpoint and a character viewpoint. For example, a bimodal bilingual produced an observer viewpoint gesture using a bent V classifier handshape that represented Sylvester climbing up a pipe, while simultaneously indicating character perspective by wiggling his head and torso as if he were climbing up the pipe. Instances such as this were coded as containing both an observer and a character perspective. However, gestures that consisted solely of character facial expressions without any accompanying manual or body gesture were not included in the analysis. Additionally, ASL signs that are produced with respect to the body and thus resemble character viewpoint (e.g., EAT, PHONE, WRITE) were not categorised as using a character perspective unless there was some other bodily indication that the participant was producing the sign from a character viewpoint, e.g., one bimodal bilingual produced the sign SEARCH while leaning to her left as if she was the character looking for something. Inter-rater agreement for presence of character viewpoint was 96.24% based on 213 independently coded gestures.

The handshape form within all coded gestures was categorised as either unmarked or marked. Unmarked handshapes were A, A-bar, B, S, 1, and 5, following Eccarius and Brentari (2006). All other handshapes were categorised as marked, including phonologically distinct variations of unmarked handshapes (e.g., bent 5). Inter-rater agreement for handshape form was 87.78% based on 90 independently coded gestures.

Statistical analysis

One-tailed, unpaired *t*-tests were used for all comparisons because we had a directional prediction, except for the analysis of beat gestures, where no difference between groups had been predicted. We used unpaired *t*-tests when the scores were distributed normally and nonparametric Mann–Whitney *U* tests when the scores were not distributed normally.

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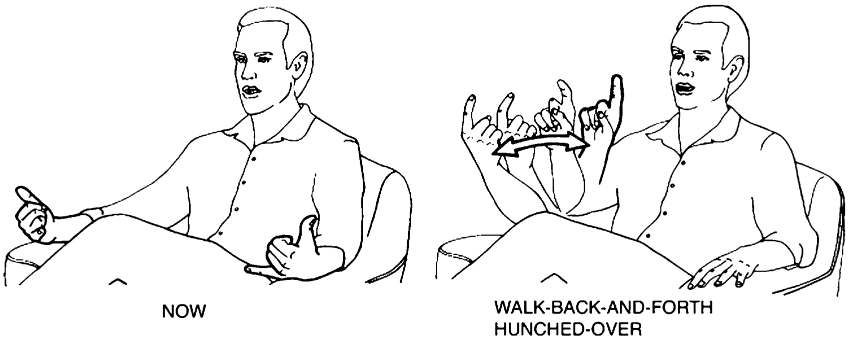
RESULTS

Nine of the thirteen bimodal bilinguals (69%) produced at least one ASL sign during their cartoon narrative. The production of ASL signs ranged from 0–12 signs with a mean of 4.15 signs. ASL signs accounted for a small portion of each participant's total gestural production ranging from 0–10.2% of all gestures, with a mean of 3.16%. A total of 54 ASL sign tokens was produced. Of these, 57% were lexical signs (e.g., BIRD, DRESS, CHASE, NOW, SEARCH) and 43% were classifier signs (e.g., a 3 handshape (the vehicle classifier) used to represent a trolley). Examples of ASL signs produced during the cartoon narrative are shown in Figure 2.

Counter to our expectations, bimodal bilinguals did not produce an overall higher rate of gesture than non-signers. The calculation of rate included all manual gestures (including those in the 'unknown' category) and ASL signs for the bilinguals. Bimodal bilinguals produced a mean of .41 gestures/signs per second ($SD = .15$) and non-signers produced .38 gestures per second ($SD = 0.15$), $t(23) = 0.63$, $p = .27$.[2]

A) So [now] he's like [you know scanning y'know the streets. He's walking back and forth] trying to figure out what to do



B) He's [lookin' around]

C) So Sylvester's walking along the wire and [one of the electric buses comes along]

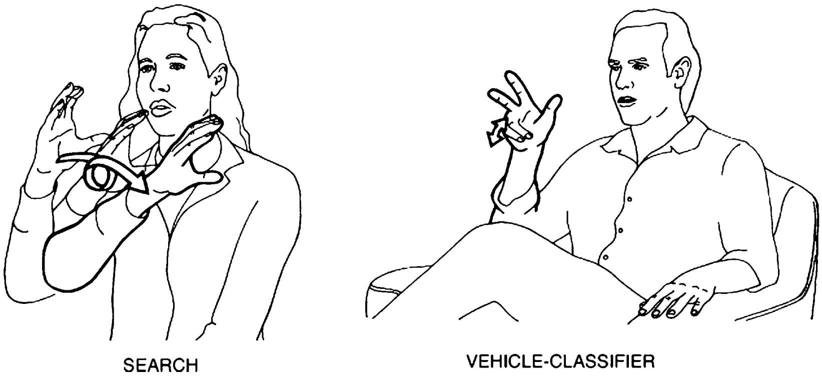


Figure 2. Examples of ASL signs produced during the cartoon narrative by ASL–English bilinguals. Brackets indicate the extent of the sign.

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[2] The analyses of rate, two-handed gestures, character viewpoint, and handshape included all gestures and ASL signs. However, the results do not change if signs are eliminated from these analyses.

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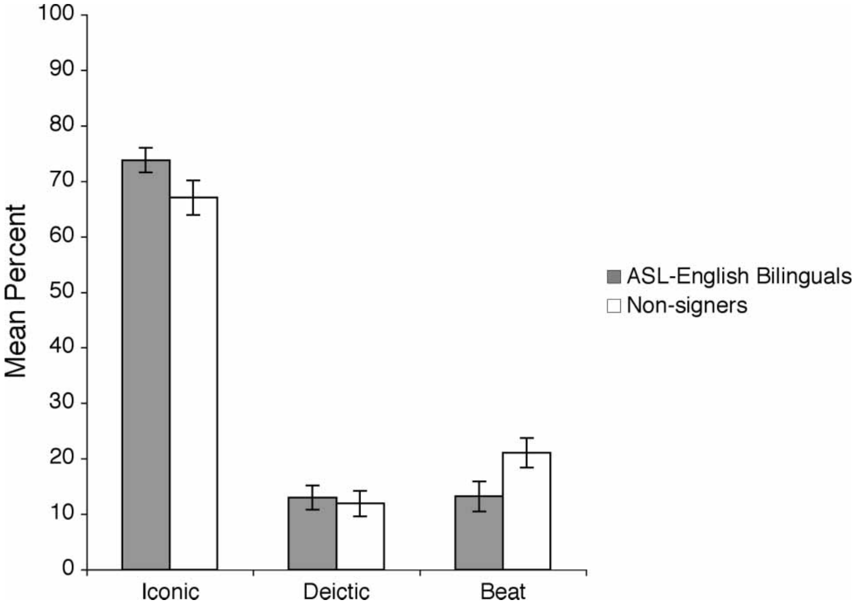

Figure 3. Mean percent of iconic, deictic, and beat gestures produced by bimodal bilinguals and non-signers. Bars indicate standard error.

Comparing the relative proportions of iconic, deictic, and beat gestures (excluding ASL signs, conventional, and unknown gestures), bimodal bilinguals produced a greater percentage of iconic gestures than non-signers, $t(23) = 1.78$, $p = .04$. Bimodal bilinguals produced a mean of 73.79% ($SD =$ 8.04), whereas non-signers produced a mean of 67.03% ($SD = 10.87$). The groups did not differ in their production of deictic gestures, $t(23) = 0.34$, $p =$ .37, with bimodal bilinguals producing a mean of 13% ($SD = 7.75$) and non-signers producing 11.92% ($SD = 8.06$). However, bimodal bilinguals were found to produce significantly fewer beat gestures with a mean of 13.21% ($SD = 9.82$) versus a mean of 21.04% ($SD = 9.25$) for non-signers, $t(23) =$ 2.05, $p = .05$ (two-tailed). See Figure 3.

Contrary to our predictions, bimodal bilinguals and non-signers did not differ significantly in their production of two-handed gestures in which each hand represented a different entity, $t(23) = 1.15$, $p = .13$. Of their total manual gestures, bimodal bilinguals produced this type of two-handed gesture with a mean of 8.88% ($SD = 6.28$) and non-signers had a mean of 6.34% ($SD = 4.57$).

As predicted, however, bimodal bilinguals produced a higher percentage of gestures using a character viewpoint (including both manual and non-manual body gestures) than non-signers, $t(23) = 1.99$, $p = .03$. Bimodal

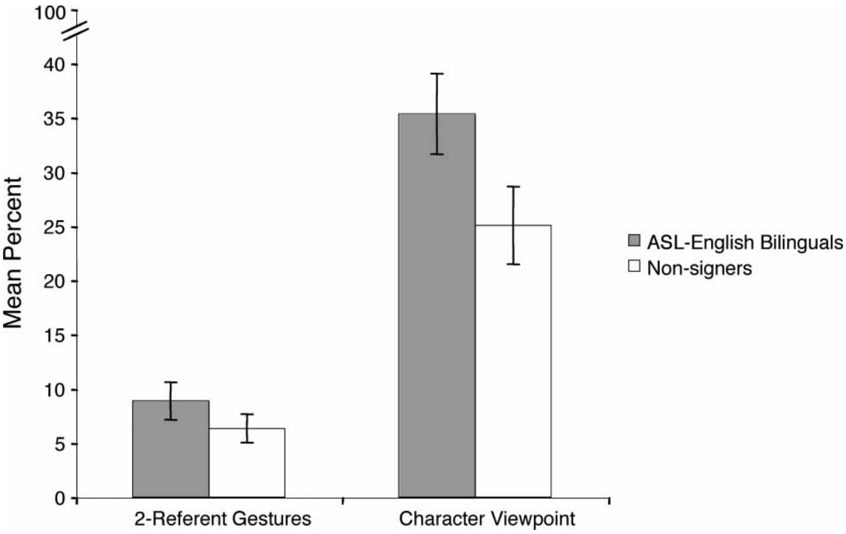

Figure 4. Semantic effects of ASL on co-speech gesture. Mean percentage of two-handed gestures representing two referents and mean percentage of gestures produced from a character viewpoint. Bars indicate standard error.

bilinguals produced 35.36% ($SD = 13.38$) of gestures with a character viewpoint, compared to 25.09% ($SD = 12.39$) for non-signers. See Figure 4.

Also as predicted, bimodal bilinguals created gestures with a greater variety of handshapes than non-signers, with a mean of 14.23 ($SD = 1.88$) handshape types versus 11.08 ($SD = 3.94$) for non-signers, $t(15) = 2.52$, $p = .01$.[3] Bimodal bilinguals produced both more marked and more unmarked handshape types than non-signers. They produced a mean of 8.62 marked types ($SD = 1.98$) compared to 6.25 ($SD = 3.11$) produced by non-signers: $t(23) = 2.29$, $p = .02$, and a mean of 5.62 unmarked types ($SD = 0.51$) versus a mean of 4.83 unmarked types ($SD = 1.12$) produced by non-signers: $U = 42$, $p = .02$.[4] See Figure 5.

Although bimodal bilinguals used a greater number of handshape types in their gestures, they produced a significantly greater percentage of gestures

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[3] A Levene test showed that the variances for bimodal bilinguals and non-signers were significantly different for the number of types of handshapes and for the percentage of unmarked handshapes. The non-signers had greater variance in both of these analyses. Therefore, the statistic reported assumes that the variances are not equal.

[4] A non-parametric Mann–Whitney *U* test was used, because a Shapiro–Wilk test showed that the scores for both the bimodal bilinguals and the non-signers were not normally distributed.

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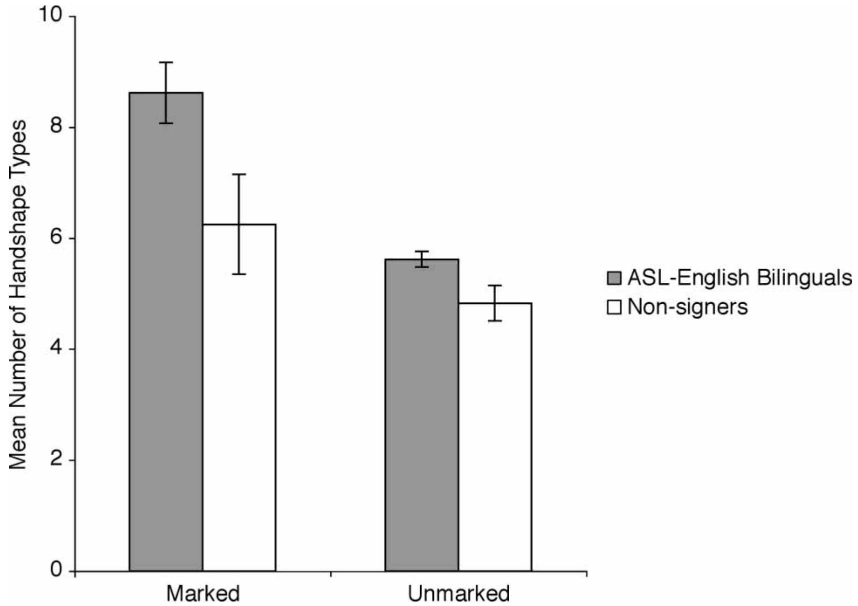

Figure 5. Mean number of marked and unmarked handshape types produced by bimodal bilinguals versus non-signers. Bars indicate standard error.

with unmarked handshapes than non-signers, $t(12) = 2.61$, $p = .01$.[5] For bimodal bilinguals, 81.51% of all handshapes were unmarked ($SD = 4.28$) compared with 68.14% for non-signers ($SD = 17.27$). See Figure 6.

DISCUSSION

Replicating the early results of Naughton (1996), we found that many bimodal bilinguals (nearly 70% in our sample) produced ASL signs simultaneously with spoken English, even when speaking with someone who they knew had no knowledge of ASL. Furthermore, many of the ASL signs that were produced were not particularly iconic and would not be recognised as meaningful by a non-signer (e.g., the signs NOW, SEARCH, or the vehicle classifier; see Figure 2). It is unlikely that such manual expressions were designed to convey information to the listener; rather, they appear to represent unintentional intrusions of American Sign Language. We hypothesise that these manual expressions were not produced by the co-speech

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[5] Battison's (1978) unmarked handshapes differ from Eccarius and Brentari's (2006) in that he also includes C and O, but excludes A-bar. However, analyses using Battison's handshapes revealed the same significant differences between ASL–English bilinguals and non-signers.

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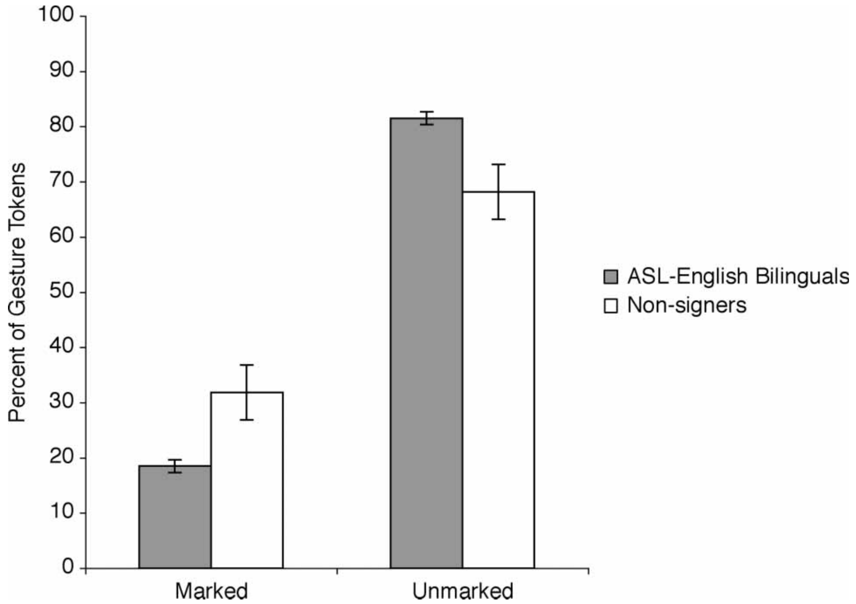

Figure 6. Percentage of gesture tokens with marked and unmarked handshapes produced by bimodal bilinguals versus non-signers. Bars indicate standard error.

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gesture system, but rather, they reflect a failure to suppress the production of ASL.

For unimodal bilinguals, a complete failure to suppress a spoken word in another language results in an unintentional code-switch in which the speaker produces a word in a language not understood by the interlocutor, for example, inserting *ahora* ('now' in Spanish) in the English sentence 'So ahora he's like, you know, scanning the streets' (parallel to the code-blend example in Figure 2A). Unintentional code-switches may be much more disruptive to communication than unintentional code-blends for several reasons. First, code-blends generally express the same information in speech and in sign (Emmorey et al., 2008), and this was true for most of the ASL–English code-blends produced here as well. Thus, a non-signing interlocutor does not miss any of the message when a code-blend is produced, unlike a non-Spanish speaking interlocutor when a Spanish code-switch is produced. Second, co-speech gestures are ubiquitous, and listeners are not surprised by manual productions that accompany speech. None of the listeners in our study expressed surprise or confusion when an ASL–English bilingual produced an ASL sign while speaking. In contrast, they would likely be surprised by the production of an unknown foreign spoken word. Given these facts, we hypothesise that bimodal bilinguals do not need to suppress signs while speaking to a non-signer as much as unimodal bilinguals need to inhibit production of words in a spoken language unknown to their interlocutor.

However, bimodal bilinguals produced many more co-speech gestures than ASL signs. Only about 3% of the bilinguals' manual productions were signs (an average of four per participant). In contrast, when bimodal bilinguals interact with each other, the number of co-speech signs (i.e., code-blends) increases dramatically. Emmorey et al. (2008) found that when bimodal bilinguals talked with each other, 36% of utterances contained at least one ASL sign, with an average of 30 single or multi-sign code-blends produced in a three-and-a-half minute language sample. In addition, bimodal bilinguals anecdotally report that ASL signs are more likely to 'slip out' when a bimodal bilingual is present in a non-signing group or when the topic under discussion is related to sign language or deafness. These patterns suggest that simultaneous selection of two lexical items for production is most likely when both languages become highly active. Although simultaneous production of lexical items does not occur for unimodal bilinguals (e.g., one cannot say *perro* and *dog* at the same time), 'congruent lexicalisation' allows morphosyntactic elements from two languages to be simultaneously produced, e.g. housekeeper*ina* with the Finnish essive case suffix (Muysken, 2000). The mechanism that controls lexical selection during bilingual language production is currently under debate (Costa, Santesteban, & Ivanova, 2006; Finkbeiner, Gollan, & Caramazza, 2006). However, our findings are consistent with Emmorey et al.'s hypothesis that the locus of lexical selection for all bilinguals is relatively late in language production. If the architecture of the bilingual language production system required that a single lexical representation be selected at the preverbal message level or at the lemma level, we would expect no ASL signs to be produced when bilinguals talk with non-signing English speakers.

The finding that gesture rate did not differ between bimodal bilinguals and non-signers was somewhat surprising given Pika et al.'s (2006) results suggesting that knowing a high frequency gesture language (French or Spanish) increases gesture rate in English, regardless of whether English is the speaker's native language or second language. However, the bilingual participants in the Pika et al. (2006) study all learned their second language later in life as adults, whereas our participants acquired both languages from birth and were native users of both English and ASL. It is possible that gesture rate for very early bilinguals is unaffected by the gesture frequency of their second language. As children, ASL–English bilinguals may establish a gesture rate in English that is commensurate with surrounding native English speakers. Equal gesture rate also suggests that ASL signs occur in the place of co-speech gestures, rather than in addition to them.

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It is possible that acquisition of ASL only impacts co-speech gesture rate when it is acquired later as a second language. Preliminary data from Casey, Emmorey, and Larrabee (2007) suggest that one year of ASL instruction leads to an increase in gesture rate when speaking English, but learning Spanish does not. Furthermore, Brown and Gullberg (2008) found that native Japanese speakers who had late-acquired and intermediate knowledge of English exhibited some English-like gesture patterns when speaking Japanese. These results suggest that late acquisition of a second language may affect co-speech gesture in ways that differ from simultaneous acquisition of two native languages.

Although gesture rate did not differ between non-signers and bimodal bilinguals, the groups differed with respect to the type of gestures produced, with ASL–English bilinguals producing more iconic gestures and more gestures from a character viewpoint than non-signers. These results support our hypothesis that the interface between the Action Generator and the Message Generator for a non-selected language can influence the semantic content of co-speech gesture. With respect to iconic gestures, we hypothesise that the ASL Message Generator must encode detailed spatial information for expression in ASL, which primes the Action Generator to produce iconic gestures, even when speaking English. We speculate that the Message Generator may be encoding information for expression in ASL, even when English is the target language for production. A recent neuroimaging study by Emmorey, Grabowski, McCullough, Ponto, Hichwa, & Damasio (2005) provides some support for this idea. Emmorey et al. (2005) found that when ASL–English bilinguals produced spatial prepositions in English, they engaged right parietal cortex, unlike monolingual English speakers. Right parietal cortex is hypothesised to be involved in processing gradient spatial information and was activated when Deaf signers and ASL–English bilinguals produced ASL locative classifier constructions. Emmorey et al. (2005) hypothesised right parietal activation was observed because bimodal bilinguals process spatial relationships for encoding in ASL, even when the task is to produce an English preposition.

The increase in gestures that encode character perspective is likely to arise from the frequent use of character perspective within role shifts during ASL narratives. Furthermore, the use of body gestures while signing (e.g., pantomimes, facial expressions of a character, whole-body movements) are most often produced within a role shift (Emmorey, 1999; Liddell & Metzger, 1998). It is possible that bimodal bilinguals favour character viewpoint gestures because these are the types of gestures that are most commonly produced during signed narratives. Thus, the nature of gesture during signing may impact the nature of gestures that are produced during spoken English narratives.

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We had also predicted that knowledge of ASL would increase the frequency of deictic gestures and two-handed gestures that represent two entities. Although bimodal bilinguals and non-signers did not differ significantly from each other for these gesture types, the means for each group were in the predicted direction. Deictic and two-handed representational gestures were relatively rare for both groups (less than 15%), and it is possible that the use of different narrative tasks might have resulted in a significant difference between groups. For example, if the narrative involved route directions or more complex spatial descriptions, we might have observed a greater use of two-handed and deictic gestures by bimodal bilinguals. Allen (2003) found that speakers produced more deictic gestures than symbolic gestures during route descriptions, and Miller and Franz (2005) found that bimanual gestures were more frequent when the content of speech was spatial than when it was non-spatial. On the other hand, it is possible that using the two hands to represent two entities might not differ for bimodal bilinguals even for complex spatial descriptions because the linear structure of speech might force the linear expression of co-speech gesture. For example, Lausberg and Kita (2003) found that participants produced more bimanual gestures without speech than with speech when they expressed the movements of animated geometrical shapes. Participants produced uni-manual gestures to depict the movement of one object at a time because they talked about one object at a time. Thus, it is possible that effects of ASL on bimanual gestures might be washed out by the linearisation pressures of English on co-speech gesture.[6]

Finally, a surprising finding was that bimodal bilinguals produced significantly fewer beat gestures than non-signers. One possible explanation is that experience with ASL (and perhaps with ASL–English code-blending) causes bimodal bilinguals to prefer to use their hands to convey communicatively transparent information, rather than to produce rhythmic gestures that do not contain semantic content. Alibali et al. (2001) found that when a speaker cannot see the listener, the rate of iconic gestures decreases, while the rate of beat gestures is unaffected. Alibali et al. (2001) interpret this result as evidence against Tuite's (1993) hypothesis that semantic content is simply overlaid on a rhythmic gestural pulse and as consistent with the view that speakers produce gestures with communicative intent. Bimodal bilinguals may be particularly sensitive to the communicative functions of gesture and may therefore increase the use of representational gestures, while decreasing the use of semantically less transparent gestures.

Our results revealed that experience with ASL not only affected the semantic content of co-speech gestures, but it also affected the form of

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[6] We thank Sotora Kita for this suggestion.

gestures. Bimodal bilinguals produced a greater variety of handshapes – both marked and unmarked – than non-signers (see Figure 5). For example, bimodal bilinguals used five handshapes that were not found in the gestures of any of the non-signers: E, open F, K, bent V, and Y. In contrast, non-signers only used two handshapes that were not found in the gestures of bimodal bilinguals: one non-signer used a 3-fingered O to represent Sylvester, and another used ILY to represent a phone receiver. We hypothesise that the increase in different handshape types by bimodal bilinguals is due to the fact that both the Action Generator and the ASL Formulator feed into the same motor control system (see Figure 1). Thus, a variety of handshapes may be readily available and easily produced when the Action Generator maps spatio-motoric representations onto the manual articulators to create co-speech gesture.

In addition, ASL–English bilinguals exhibited a greater preference for unmarked handshapes than non-signers (see Figure 6). We hypothesise that the common occurrence of unmarked handshapes within ASL signs primes the Action Generator to select such handshapes when creating co-speech gestures. When mapping meaning to form, the co-speech gesture system, unlike the sign language production system, maps spatio-motoric imagery directly to manual articulation without constraints from stored phonological representations. However, the phonological structure of ASL may influence the form of co-speech gesture because the parallel meaning-to-form mapping frequently involves articulation of unmarked handshapes. No such parallel system exists for non-signers, and thus they are free to produce co-speech gestures with more marked handshapes.

Overall, the results indicate that native acquisition of American Sign Language changes co-speech gesture making it resemble ASL through the insertion of signs and by increasing the use of iconic gestures, character viewpoint, handshape variety, and use of unmarked handshapes. We hypothesise that these differences arise because ASL is activated to some extent while bimodal bilinguals speak English, perhaps due to use of the hands to create co-speech (non-ASL) gestures. We hypothesise that the semantic and form differences between the gestures of bimodal bilinguals and non-signers arise from an interaction between the ASL language production system and the co-speech gesture system. Further research is needed to determine whether acquisition of ASL as a second language in adulthood changes the nature of co-speech gesture in the same way and to the same extent. Furthermore, it is also possible that an individual's pattern of co-speech gesture can impact how ASL is acquired (see Taub, Galvan, Piñar, & Mather, 2006, for some preliminary evidence suggesting such an

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effect). In sum, the study of co-speech gestures produced by ASL–English bilinguals can provide novel insight into the processes by which these gestures are created.

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APPENDIX A

Illustrations of handshapes referred to in the paper


A


A-bar


B


E


open F


K


3-fingered O


S


V


bent V


Y


ILY


1


3


5


bent 5

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APPENDIX B

Items coded as ASL signs

Lexical signs

BIRD
BOX
CHASE
DRESS
EAT
ELIMINATE
HEAR
INTERSECTION
JUMP
LOOK (4 occurrences)
LOOK-AT-EACH-OTHER (2 occurrences)
MEASURE
NEXT
NOW
OPEN-DOOR (2 occurrences)
PHONE
ROLL (3 occurrences)
SCENE-FADE-OUT (3 occurrences)
SCENE-OPENS
SEARCH
UM
WRITE

Classifier constructions

animal classifier bent V handshape (11 occurrences)
animal classifier bent V & vehicle classifier 3 handshapes for Sylvester and trolley
bent legs classifier X & X handshapes for running
upright animal classifier 1 to X handshape for Sylvester walking
upright animal classifier 1 handshape for Sylvester (4 occurrences)
legs classifier 1 & 1 handshapes for walking legs
vehicle classifier 3 handshape for trolley (2 occurrences)
vehicle classifier 3 & upright animal classifier 1 handshapes for trolley and Sylvester
flat object classifier 5 & 5 handshapes for rows of mail slots